UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

HT

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
08/825,362	03/28/97	LIAO M	761/P7US/CVD

MM42/1230

PATENT COUNSEL
APPLIED MATERIALS INC
3050 BOWERS AVENUE
PO BOX 450A
SANTA CLARA CA 95052

EXAMINER	
QUACH, T	
ART UNIT	**PAPER NUMBER**
2814	

DATE MAILED: 12/30/99

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

Office Action Summary

Application No.	Applicant(s)
08/825,360	Liao et al.
Examiner	**Group Art Unit**
Quach, T.	2814

☒ Responsive to communication(s) filed on *Oct 20, 1999*.

☐ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire *three* month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claims

☒ Claim(s) *21-53* is/are pending in the application.

Of the above, claim(s) _____ is/are withdrawn from consideration.

☐ Claim(s) _____ is/are allowed.

☒ Claim(s) *21-53* is/are rejected.

☐ Claim(s) _____ is/are objected to.

☐ Claims _____ are subject to restriction or election requirement.

Application Papers

☐ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The drawing(s) filed on _____ is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on _____ is ☐approved ☐disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) _____.

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: _____.

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☒ Notice of References Cited, PTO-892

☐ Information Disclosure Statement(s), PTO-1449, Paper No(s). _____

☐ Interview Summary, PTO-413

☐ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

--- SEE OFFICE ACTION ON THE FOLLOWING PAGES ---

DETAILED ACTION

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless --
>
> (e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent.

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(f) or (g) prior art under 35 U.S.C. 103(a).

Claims 21-23 and 40-45 are rejected under 35 U.S.C. 102(e) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Bai et al.

Bai et al. teach forming substrate 40, forming dielectric 41, patterning the dielectric layer to form trench 47, forming capturing layer 43 of titanium material having thickness between 5Å and 500Å, forming blocking layer of titanium nitride havign thickness between 10Å and 500Å. See column 5 lines 1-33, column 8 lines 7-57, Fig. 3 to 10 lines 4-49.

Note that the inventive feature of the capturing layer, the blocking layer, the refractory metal, the refractory metal nitride, and the layer thicknesses as characterized correspond to the claimed invention in claims 1-20 of Bai et al., column 10 line 5 to column 12 line 32, e.g., claim 1 line 4-11, claim 3 line 3, claim 4 line 3, claim 9 lines 1-4, claim 10 lines 4-12, claim 11 line 3-5, claim 16 lines 1-13, claim 17 line 3, claim 18 line 3, claims 19 and 20 lines 1-4.

The claimed parameters, e.g., thickness of less than 130Å, width less than 3000 Å, aspect ratios greater than 3.33 is anticipated given the range taught in Bai et al. Any range and combined range claimed not anticipated by Bai et al. would have been obvious to one skilled in the art given the teaching of Bai et al., e.g., column 5 lines 6 et seq., to optimize the barrier thickness to obtain the desired resistance of the interconnect. Any parameters not anticipated are deemed to have been obvious and would have been within the purview of one skilled in the art to obtain the desired trench width and aspect ratio.

The Bai et al reference is a U.S. patent that claims the rejected invention. An affidavit or declaration is inappropriate under 37 CFR 1.131(a) when the patent is claiming the same patentable invention, see MPEP § 2306. The patent can only be overcome by establishing priority

of invention through interference proceedings. See MPEP Chapter 2300 for information on initiating interference proceedings.

Claims 24-31, 48-50, 52, and 53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bai et al. as applied to claims 21-23 and 40-45 above, and further in view of Ho et al., Hower et al., and Fu et al.

The reference as applied above does not recite plasma annealing of the titanium nitride barrier layer.

Ho et al. teach plasma reaction of titanium nitride in suitable gases, e.g., oxygen, nitrogen, to fill the grain boundaries hence improving barrier characteristics. See column 7 line 28 to column 8. The use of nitrogen or hydrogen as the gas to stuff the nitrogen is also taught. See column 7 lines 4-27, column 10 lines 3-20.

Hower et al. teach plasma treatment of titanium nitride to reduce silicon movement therethrough and to reduce interface defects. See column 2 line 56 to column 3 line 28 to column 3 line 30.

Fu et al. teach plasma treatment of titanium nitride in argon wherein the treament smooths the TiN surface and improves wettability. See column 2 line 48 to column 3 line 16.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the Bai et al. process to have employed plasma treatment of the titanium nitride since such is conventional and advantageous to improve barrier characteristics and wettability as taught by Ho et al., Hower et al., and Fu et al. It would have been obvious and would have been within

the purview of one skilled in the art to have selected the desired conventional plasmas, the conventional electrical biasing and rf signal, to have employed single chamber for deposition and annealing, and to employ conventional alternative metal nitrides. Alternatively, official notice is given regarding any conventional plasmas, alternative metal nitrides enumerated in the claims that are not recited above and the use of electrical biasing and rf signal as claimed.

Claims 32-39 and 51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bai et al. and further in view of Ho et al., Hower et al., and Fu et al.

The references are applied as above. Note further that Ho et al. teach the use of two anneals, e.g., first anneal of nitrogen and second anneal of hydrogen. See e.g., column 7 lines 4-27, column 10 lines 8-20.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed two plasma anneals since such would permit the stuffing of the gases in the titanium nitride to improve barrier characteristics. The use of gas plasma is conventional and advantageous wherein the plasma would increase the stuffing in the barrier material.

Claims 46-47 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bai et al. as applied to claims 21-23, 40-45 above, and further in view of Dixit et al.

The reference as applied above does not recite the upper metallization layer of tungsten.

Dixit et al. teach the filling of tungsten on the titanium/titanium nitride to complete interconnection having low resistivity. See column 5 lines 3-57, column 7 lines 34 to column 8 line 13.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed tungsten as interconnection since such is conventional and advantageous as taught in Dixit et al.

Claims 21-23 and 40-47 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dixit et al. or Sandhu et al. taken with Suguro et al.

Dixit et al. teach forming channels 16 through insulating layer 14, forming titanium 18 e.g., about 100 angstroms, forming titanium nitride thereon, e.g., to about 250 angstroms using conventional deposition method. Well known alternative refractory metals and metal nitrides and alternative deposition techniques are also shown. Subsequent formation of metallization such as tungsten and etchback is also taught. See column 4 line 64 to column 7 line 11.

Sandhu et al. also teach forming channels 31 in insulating layer 32, forming titanium layer 35, forming titanium nitride barrier layer 41, forming tungsten or alumium or copper thereon. See column 6 line 61 to column 7 line 33.

Thus Dixit et al. or Sandhu et al. lack anticipation in that the metal nitride having thickness or less than 130 angstroms is not taught. Dixit et al. employ the preferred thickness of 250 angstroms for the barrier nitride.

Suguro et al. teach the use of TiN as barrier layer wherein optimization of layer thickness of the titanium nitride is also taught, including the use of TiN thickness of 4 nm, 7 nm, and 10 nm, see the abstract, the paragraph bridging page 280 and 281, wherein TiN thickness as low as 10 nm was employed.

It would have been obvious to one skilled in the art in practicing Dixit et al. or Sandhu et al. to have selected the desired thickness of the nitride barrier layer since such thickness variation and optimization is well within the purview of one skilled in the art as evidenced by Suguro et al., including the selection of the thickness claimed of less than 13 nm, given the thicknesses taught by Suguro et al. The claimed parameters, e.g., thickness of less than 130Å, thus would have been obvious given the range taught in Suguro et al. The use of thin adhesion layer employing conventional processing would have been obvious given the teaching of Dixit et al. wherein such thickness optimization would have been obvious and would have been within the purview of one skilled in the art. The use of alternative refractory metals and metal nitrides, of conventional deposition methods, would have been obvious and would correspond to obvious alternative materials and deposition and planarization process and as such would have been within the purview of one skilled in the art. The selection of high aspect ratio and reduced submicron trench width and of etchback of the respective layers to the extent desired to form plugs employing conventional processing is well known in the art and is well within the purview of one skilled in the art and as such would have been obvious.

Claims 24-31, 48-50, 52, and 53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dixit et al. or Sandhu et al. taken with Suguro et al. as applied to claims 21-23 and 40-47 above, and further in view of Ho et al., Hower et al., and Fu et al.

The reference as applied above does not recite plasma annealing of the titanium nitride barrier layer.

Ho et al. teach plasma reaction of titanium nitride in suitable gases, e.g., oxygen, nitrogen, to fill the grain boundaries hence improving barrier characteristics. See column 7 line 28 to column 8. The use of nitrogen or hydrogen as the gas to stuff the nitrogen is also taught. See column 7 lines 4-27, column 10 lines 3-20.

Hower et al. teach plasma treatment of titanium nitride to reduce silicon movement therethrough and to reduce interface defects. See column 2 line 56 to column 3 line 28 to column 3 line 30.

Fu et al. teach plasma treatment of titanium nitride in argon wherein the treament smooths the TiN surface and improves wettability. See column 2 line 48 to column 3 line 16.

The reasons applied to claims 21-23 and 40-47 apply, and additionally, it would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed plasma treatment of the titanium nitride since such is conventional and advantageous to improve barrier characteristics and wettability as taught by Ho et al., Hower et al., and Fu et al. It would have been obvious and would have been within the purview of one skilled in the art to have selected the desired conventional plasmas, the conventional electrical

biasing and rf signal, to have employed single chamber for deposition and annealing, and to employ conventional alternative metal nitrides. Alternatively, official notice is given regarding any conventional plasmas, alternative metal nitrides enumerated in the claims that are not recited above and the use of electrical biasing and rf signal as claimed.

Claims 32-39 and 51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dixit et al. or Sandhu et al. taken with Suguro et al. and further in view of Ho et al., Hower et al., and Fu et al.

The references are applied as above. Note further that Ho et al. teach the use of two anneals, e.g., first anneal of nitrogen and second anneal of hydrogen. See e.g., column 7 lines 4-27, column 10 lines 8-20.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed two plasma anneals since such would permit the stuffing of the gases in the titanium nitride to improve barrier characteristics. The use of gas plasma is conventional and advantageous wherein the plasma would increase the stuffing in the barrier material.

Applicant's arguments with respect to claims 21-53 have been considered but are moot in view of the new ground(s) of rejection.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Quach whose telephone number is (703) 308-1096. The examiner can normally be reached on Monday through Friday from 8:30 to 5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri, can be reached on (703) 306-2794. The fax phone number for the organization where this application or proceeding is assigned is (703) 308-7722 or (703) 308-7724.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0956.

Tuan Quach
Primary Examiner